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MARYLAND WATER SUPPLY AND DEMAND STUDY

Part I
BASIC DATA

Volume 6
GENERAL REFERENCE SECTION

MARYLAND STATE PLANNING DEPARTMENT

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STATE OF MARYLAND

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MARYLAND WATER SUPPLY AND DEMAND STUDY

Part I - BASIC DATA

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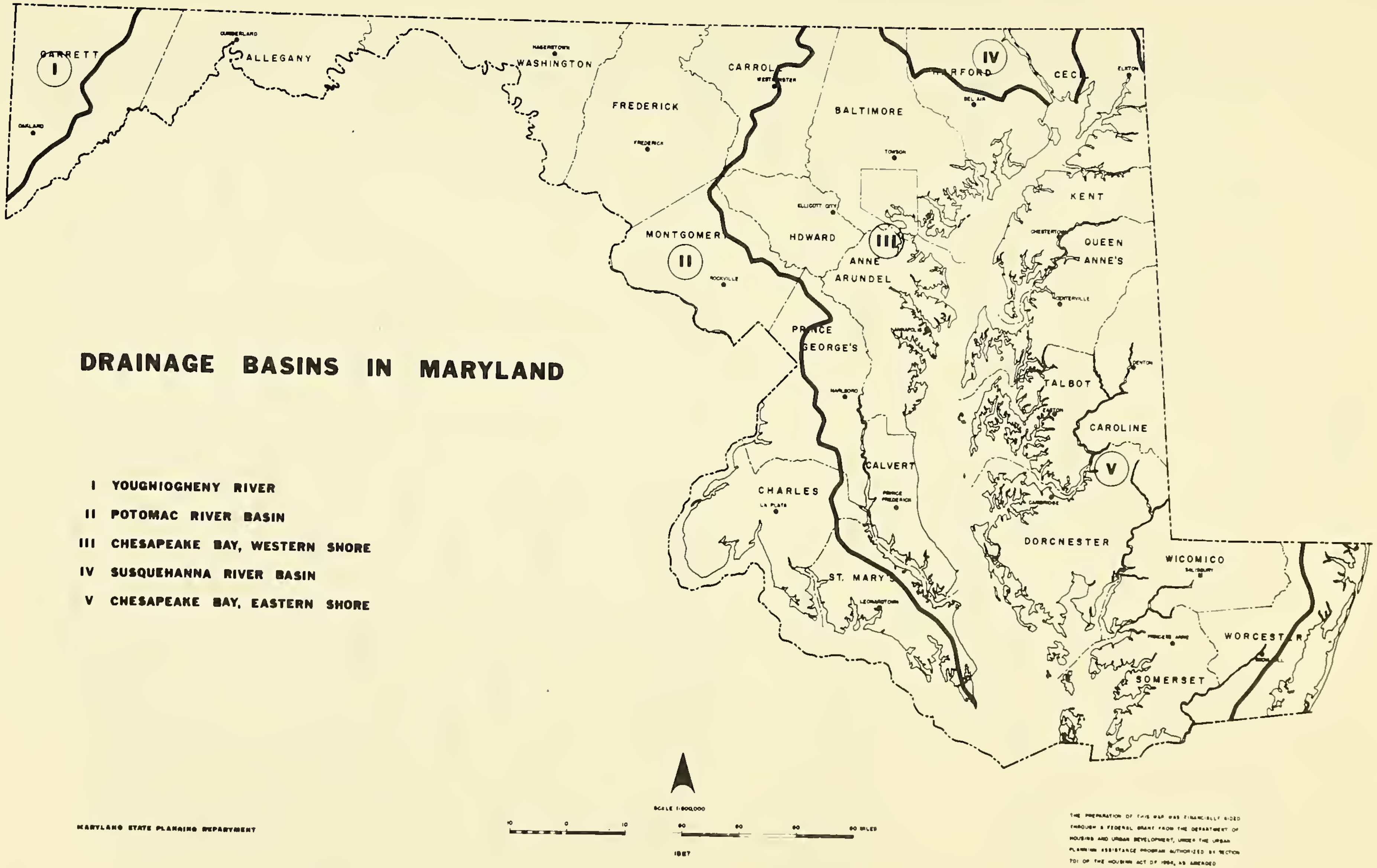

FIGURE 1. Maryland Water Supply and Demand Study Water Resource Areas.

INTRODUCTION

For purposes of this study, Maryland was divided into the following water resource areas: the Susquehanna, Chesapeake Bay West, Potomac River basin, Youghiogheny River basin, and the Eastern Shore (Figure 1). These study areas are discussed in the preceding five report volumes. This General Reference Section contains material which otherwise would have been duplicated by each report. Reference is made throughout the preceding reports to appropriate passages in this volume.

DESCRIPTION OF APPENDICES

Each of the study area reports contains a narrative chapter and a set of appendices. A description of the appendices and the procedures used in their preparation follows.

Appendices A and B - Master List of Locations on Surface Waterways

In an inventory of water resources it is important to know the location as well as the quantitative aspects of supply and use. The location factor is needed for evaluating the relationship between use and re-use of the same water. A frequent criticism of water-use studies is that they generally do not account for the re-use factor, and therefore may indicate total use of water in excess of the supply. Consequently, such study results may create a false impression of water shortage where none exists.

Comparison of water quantities available with those being used are valueless in assessing water problems without specific information on relative locations of supply and demand points. In the humid Eastern United States area-wide comparisons of water supply and use may indicate relative abundance of water to meet foreseeable needs, while disguising severe shortages at specific points within the area considered.

Finally, it is important to know how a given water use affects or is affected by other water uses from the standpoint of quality as well as quantity. This knowledge depends largely on data locating points of water use relative to each other, to available water supplies, and to water control structures. For these reasons, the preceding five inventory volumes on water resources have been as much concerned with locations as with quantitative data on water supplies and uses.

The method of inventory devised for surface waters in this study includes a listing of all items of interest in hydrologic sequence - from headwaters to the mouth - along the course of each stream. With only a few exceptions, the procedure used follows that of the U. S. Geological Survey (USGS) in listing stream gaging stations.

The items listed in Appendix A include gaging stations, water intakes, waste outfalls, water-quality sampling stations, political boundaries (state, county and city lines), dams and proposed dam sites, bridges and other prominent points of interest. If known, the head of tide and the upstream limit of license-free tidewater fishing as prescribed by the responsible regulatory agency is included. The location of tributaries relative to each other and to other items listed in the Appendix is also included.

The items of interest to this study are located by identification of the name of the stream on which the item is found and by determination of the item's distance above the mouth of its respective waterway within the surface drainage system. As an example, locations on the eastern and western shores of the Chesapeake Bay are identified by their distance from the mouth of the Bay, established as the midpoint in the shipping channel on a line from Cape Charles and Cape Henry in Virginia. Distances were measured along the main shipping channel up the Bay to an east-west line drawn from the point in question to the channel. Locations on tributaries discharging directly into Chesapeake Bay are identified by two mileage figures separated by a hyphen. The first figure represents the distance up the Bay to the mouth of the tributary; the second shows the mileage from the mouth of the tributary to the point in question. On successively smaller tributaries, points of interest are assigned three, four, or more mileage figures - all separated by hyphens - depending on the number of different waterways one would travel in going by water from the mouth of Chesapeake Bay to the locations in question. This same procedure is used in each of the study-area reports.

It has been determined that this mileage location system will be compatible with the stream indexing system now being developed by the Federal Water Pollution Control Administration of the U. S. Department of Interior and the Maryland Department of Water Resources for use in the storage and retrieval of water-quality data. Therefore, the mileage data presented in this report can be easily transferred to the FWPCA system of machine storage when the system is put into use. The machine system will involve the use of identification numbers other than mileage figures to facilitate data retrieval by machine methods. When it is desired to transfer mileage data information from one system to another, it will be a relatively simple matter to assign the identification numbers to the locations listed in this report.

The position of water intakes is significant in the vicinity of the head of tide (whether above or below the head of tide) with respect to wastes discharged into the tidal reaches. Such wastes may affect the quality of a water supply taken from within the tidal reach but would not affect a supply taken above the head of tide.

Wastes discharged into tidal waterways below the limits of sea-water intrusion represent a permanent loss from the available fresh water resources of the area. This is especially important in Maryland because the heaviest concentrations of population and industry and consequent water use are located on or near tidal waters and discharge their used water into brackish waters. The scheme used to locate and tabulate waste discharges reveals these losses of water which can be recovered only by prohibitively expansive methods of saline water conversion.

Streamflows at various points of interest along the streams lacking adequate drainage data can be approximated by interpolation and extrapolation of distances between stream gages.

Bridges are included in the tabulations with their locations because they afford access to the stream for purposes of gaging streamflow and measuring water quality. Also, bridges are potential sites of accidental or intentional dumping of dangerous materials into water supplies. Location of such sites with their relative distances and position from water intakes is information of vital concern from the standpoint of both public health and civil defense. Knowledge of bridge locations (mileages) is useful in determining time of travel and velocity of water flowing in a stream for purposes of self-purification, flood routing, and other studies. Bridges located in stream reaches that would be inundated by proposed reservoirs must be considered and possibly relocated. Bridges are subject to damage by floods and therefore require consideration in multi-purpose river developments which include flood control as a function. Bridges affect and are affected by navigation. Finally, the known location of bridges is a definite aid in locating other items of interest in a water-resource inventory.

The mileage data have generally been recorded to the nearest tenth of a mile. Occasionally, in order to differentiate between two locations less than 0.1 mile apart, mileages have been estimated to hundredths of a mile. These should be taken as showing only relative positions in a given reach of a stream; none of the mileage data should be assumed to be highly accurate. Most of the mileages were measured on USGS 7.5-minute quadrangle maps. Repetitive measurements indicated variations as much as three per cent for distances of about 10 miles.

Nearly every stream having a name as shown on USGS 7.5-minute quadrangle maps, or on any other map available for areas not covered by the 7.5-minute series, has been listed in Appendix A of each study-area report. Many unnamed streams are included also. The mouth of each tributary is listed twice at the proper mileage on the parent stream. The first listing represents the point on the main stream immediately upstream of the confluence with the tributary. The second listing represents the point on the main stream immediately below the confluence. Between the two are listed all items of interest on the tributary. The double listing on the parent stream provides for separate tabulation of two drainage areas, the first excluding and the second including the drainage area of the tributary.

At least two entries are included for each listed stream. The first entry is the head of the stream and the other is the mouth. If any other items of interest occur between the head and the mouth of a stream, they appear in hydrologic sequence (downstream). Remember, however, the appropriate mileage figure is calculated from the mouth of the stream.

The mileage figure for the head waters of a stream, where shown, represents the distance from the mouth of the stream to the upper limit of the perennial stream as mapped by the USGS 7.5-minute series, if available.

the distance to the head waters of many streams was not measured due to time limitations. Spaces for these missing data are underlined to show their proper indention corresponding to the order or "magnitude" of the stream.

The mileage at the mouth of a given stream as measured on that stream is always listed as "0.0." This entry always immediately precedes the second listing of the mouth of the tributary at its mileage measured along the parent stream. Thus, each stream measured has three entries listing its mouth, one for the stream itself and two for the parent stream.

The order or magnitude of the waterways is shown by indention. Each indention represents one order. For example, Chesapeake Bay is a first order waterway and streams which discharge directly into the Bay are second order waterways. Some modification of this procedure was necessary because of the size of tributary waterways. Although both the Susquehanna and the Potomac rivers are tributaries of the Bay, they were considered first order waterways for purposes of this study because of their size. An exception also was made in the case of the Youghiogheny which is a tributary of the Ohio system. It was considered a first order stream in this study since the confluence of the Youghiogheny with the Monogahela River is some 50 miles below the state line. Similarly, streams which flow directly into second order streams are third order streams, and so on. Fifth and sixth order streams with geographic names are rare in the State of Maryland.

In addition to river mileages, the Master Listing of streams shows the data that are readily available on specific drainage areas. These date were obtained largely from the 1933 report of the Water Resources Commission of Maryland. Supplemental data on drainage areas were furnished by the

USGS District Office at College Park, Maryland. Drainage data were available for relatively few locations of interest in this study. Although knowledge of drainage areas is generally as important as knowledge of river mileages, no attempt was made to measure the former in this study; time would not permit it.

State and county boundaries are also indicated in the Master List - state borders by a solid line and counties by a broken line.

The Master List is designed to show data which are needed but missing as well as data which are presently available. The data tabulating system allows for unlimited expansion as needed to include new items of interest on streams already listed or on streams which may have been omitted from the present listing.

The types of data outlined above and the tabular system of presentation used in the Master List should prove to be useful tools in the planning and regulatory activities necessary for the conservation and development of the water resources of the State of Maryland. Now that these data have been thus organized, they show data available and data needed. To the extent possible with the available data, the Master List shows where surface runoff has been or is being measured in relation to points of withdrawal and instream uses. Thus, together with other tabulations showing quantitative values of streamflow and withdrawal uses, the Master List readily reveals where and how much water is available and where and how much is being used.

The information shown in Appendix B includes the name of the stream, the location of the intake (listed in hydrologic sequence and indicated by the river mileage system), the name of the water user supplied through each intake, and the average amount of water withdrawn daily, if known. It is probable that some existing intakes have been omitted because they are unknown to agencies cooperating in this study. Such omissions reflect the absence of any continuing inventory on water uses in the past in the State of Maryland.

Liquid wastes discharged into surface waterways of the State also are listed in Appendix B. Waste water outfalls are shown in hydrologic sequence to reveal their locations relative to water intakes, to other outfalls, to streamflow gaging stations and to water quality sampling stations. The location of each outfall, like that of the water intakes, is shown by means of the distance above the mouth of the stream on which it is located. In addition to the stream mileage, the name of the stream receiving the discharge, the name of the waste source, and the mean daily rate of waste discharge are presented when known.

There are many more outfalls than water intakes listed in Appendix B. There are several reasons for this. First, many water users obtain their supplies from wells. Therefore, there isn't a surface water intake. Second, many industrial users obtain water from public systems, thus eliminating a private intake. Finally, quite possibly many water intakes are unknown. Therefore, they do not appear in the list.

Appendices B and D - Streamflow Data

Streamflow Records (Appendix B) - All known streamflow gaging stations which are or have been operated in the State are listed also in Appendix B. The list includes partial record stations at which only limited data on streamflow have been collected. The list shows, in addition to the location of the gaging site, low flows based on two low-flow criteria. The first is the minimum daily flow of record at the gaging station, and the other is the lower five percentile among the daily streamflows; that is, the flow which is expected to be exceeded by 95 per cent of the daily streamflows over a long period of record.

The minimum daily flows were obtained from the "Water-Supply Papers" and similar publications of the U. S. Geological Survey. When the value shown for the gaging station nearest a given water intake is adjusted to correspond to the latter location, it can be compared with the rate of withdrawal to provide an indication of the surplus or deficit of water that can be expected during a minimum flow period. A deficit would indicate a need for storage and streamflow regulation if water use at the rate shown is to be sustained. A valid determination of the need for storage requires comparison of the maximum withdrawal rate with the coincident minimum streamflow rate. The first of these two rates is not generally available. The withdrawal rates listed in Appendix B are average rates, the latest available. The minimum daily flows of record do not always coincide with the maximum withdrawal rates. Therefore, comparison of the withdrawal rates and minimum daily flows as listed in this report gives only a crude indication of surplus or deficiency of water supply. For more meaningful comparisons, data are needed to show seasonal distribution of water use.

To estimate the critical streamflow at a given ungaged location, the usual method is to multiply the corresponding streamflow for a nearby gaging station by the ratio of the ungaged drainage area to the gaged area. The available drainage area data are listed in Appendix A. Drainage areas above each gaging site are known, but rarely is the drainage area above a specific water intake or waste outfall known. Therefore, comparisons of water-use or waste-discharge rates with critical streamflow rates at most intakes and outfalls require the determination of drainage areas. The determination of these areas is beyond the scope of the present investigation.

Standard methods for drainage area determinations have been adopted by water resource agencies of the Federal Government (Federal Inter-Agency River Basins Committee, 1951).

The five-percentile flows listed in Appendix B are for the base period 1913-1957 as presented by Darling (1962). The five-percentile value is the design streamflow criterion used by the Maryland State Department of Health in determining treatment requirements for wastes to be discharged into a surface waterway. The design streamflow shows the degree of dilution the wastes will receive in the stream about 95 per cent of the time. This dilution factor serves in the determination of the waste load that can be discharged safely, and thus is a parameter in fixing the degree of waste treatment. The assumption is made that during the five per cent of the days when the streamflow is less than the design flow, the stream water-quality degradation because of lesser dilution is more acceptable than drastically increased cost of waste treatment.

Storage Requirements for Sustained Yields (Appendix D) - Since natural streamflows vary widely compared to demands for water, natural flows are often inadequate to meet water needs. The usual remedy is to provide storage facilities in which water is collected and stored during periods of surplus, and later released during periods of deficient natural flow.

The amount of artificial storage capacity required is a function of the sustained yield desired and the variability of the natural flow. It is also a function of the duration and frequency of periods for which yields less than the desired level can be tolerated.

Storage requirements for sustaining various gross yields at stream gaging stations have been computed for most gages in Maryland having adequate records. For this purpose frequencies of low flows for various duration periods were taken from a report by Darling (1962). These data were used to construct "frequency-mass curves" by the Martin and Hulme method (1957). The frequency-mass curve incorporates the concepts of chance and average recurrence interval of low flows similar to the mass diagram of Rippl (1883). The mass diagram is a curve showing the cumulative flow of a stream as a function of sequential time. The frequency-mass curve, on the other hand, shows the cumulative flow as a function of the duration of seasonal droughts, each such curve representing a given recurrence interval. Points on a frequency-mass curve do not represent a time series. Comparison of either the Rippl diagram or the frequency-mass curve with the cumulative draft line (the desired yield line) shows the deficiency of natural flow for specific times in the case of the former and at the end of drought periods of various durations in the latter. The maximum deficiency in either case represents the storage capacity required to sustain the desired yield.

Unfortunately, Darling (1962) did not present data showing low flows for periods greater than 274 days. Frequency-mass curves constructed from Darling's flow-frequency data showed storage requirements for relatively low yields only, generally up to 50 per cent of the mean annual flow. Since it is frequently desirable to sustain yields in excess of this level, a method was sought to extend the results from the frequency-mass curves to higher yields.

A method was found which uses the generalized storage tables developed and first published by Allen Hazen (1920) and recently republished by Richard Hazen (1956), who stated that the tables "... have been checked repeatedly for streams in northeastern United States and can be used with confidence."

Hazen's tables require the use of two parameters of streamflow, the coefficient of variation of the annual mean flows, and a so-called ground-storage constant. The coefficient of variation is defined as the standard deviation of the annual mean flows divided by the mean annual flow. Hazen's ground-storage constant, expressed in days, is a measure of the ability of the natural hydrolcgic system to store water and regulate streamflow during drought periods. Actually, factors other than ground storage are involved in natural regulation of streamflow. For this reason, Hazen's "ground-storage constant" will be referred to as the "natural-storage constant" hereafter in this report.

The coefficient of variation correlates well with the long-term artificial storage required to sustain flows in dry years following wet years. The higher the coefficient of variation, the higher the long-term storage required to sustain a given yield. The natural-storage constant, on the other hand, is correlated with the seasonal storage requirements - the higher the natural-storage constant, the lower the amount of artificial storage required to sustain a given yield throughout a seasonal dry period.

Hazen's tables present storage requirements in terms of the mean annual flow for combinations of desired yield and the coefficient of variation. The basic value from the table is then adjusted for the degree of natural regulation in the stream as represented by the natural-storage constant. Thus, use of the table requires prior knowledge of the natural-storage constant.

In the current study, the natural-storage constant was found as follows:

(1) First, the amount of storage required to sustain a gross yield of 50 per cent of the mean annual flow was found by the frequency-mass-curve method.

(2) Next, the basic storage ratio for a yield of 50 per cent was taken from Hazen's table for the previously computed coefficient of variation.

(3) The natural storage in terms of mean annual flow was found by subtracting item (1) from item (2). This difference is called the "actual deduction."

(4) The natural storage in terms of the mean annual flow as found in step (3), was converted to days of storage from the relation:

$$\frac{\text{Actual days of storage}}{\text{30 days of storage}} = \frac{\text{Actual deduction}}{\text{30-day deduction}}$$

in which the "30-day deduction" is the value of the deduction for natural storage listed in Hazen's table, in terms of mean annual flow, corresponding to a natural-storage constant of 30 days.

Once found for the 50 per cent yield, the natural-storage constant (in days) was used to compute the natural-storage deduction for higher gross yields of 70 and 90 per cent of the mean annual flow. For this purpose, the same proportion shown above was used. In this case, however, the "actual days of storage" is known, and the unknown to be found is the numerator of the right-hand ratio of the proportion.

Appendix D lists the artificial storage requirements for each of the major drainage basins in the State. The values of storage presented consider both evaporation losses and seepage losses.

The storage values are given in terms of mean annual flow, but can be converted easily into volumes by use of the relation:

$$\frac{V_s}{M} = R_s$$

in which V_s = volume of storage required;

M = mean annual flow, in acre-feet; and

R_s = storage ratio (from table)

For example, the table for the Bush River sub-basin (Volume 1, Appendix D) gives a storage ratio of 0.826 for a gross yield of 0.9M on Bynum Run at Bel Air, Maryland.

$$M = 10.8 \text{ cfs (from column 3)}$$

$$= 10.8 \text{ ft.}^3 \times \text{sec}^{-1}$$

$$= 10.8 \text{ ft.}^3 \times \text{sec}^{-1} \times \frac{1.98 \text{ acre-feet} \times \text{day}^{-1}}{\text{ft.}^3 \times \text{sec}^{-1}} \times \frac{365 \text{ days}}{\text{year}}$$

$$M = 10.8 \times 1.98 \times 365 \text{ acre-feet/year}$$

$$V_s = R_s M = 0.826 \times 10.8 \times 1.98 \times 365 \text{ acre-feet/year}$$

$$= 6{,}450 \text{ acre-feet/year}$$

This means that a reservoir holding 6,450 acre-feet of water on Bynum Run above the stream gage at Bel Air, Maryland, will provide a gross yield of 9.7 cfs (equal to 10.8 cfs times 0.9) for 19 out of every 20 years, on the average. Except for seepage and evaporation losses, the 9.7 cfs would be sustained at the gage.

Inasmuch as the storage ratios listed in the tables for yields above 50 per cent of mean annual flow were found by use of Hazen's generalized tables, they cannot be assigned the same degree of reliability as the storage ratios shown for yields of 50 per cent or less, which were determined from frequency-mass curves based on actual streamflow records for the specific streams involved. However, because the 50 per cent yield storage ratio determined from the frequency-mass curve was used in computing the natural-storage constant, and because this same natural-storage constant was used to determine the required artificial storage for yields above 50 per cent, all storage ratios listed in the tables form a continuous series which can be plotted as a smooth curve. This indicates a reasonable extension of the lower storage ratios obtained from the frequency-mass curve. The reliability of the extended storage ratios (those for yields above 50 per cent of mean annual flow) is high for yields only slightly greater than 50 per cent, but decreases for higher yield percentages.

It is emphasized that the Appendix D tables apply to a recurrence interval of 20 years. That is, a desired gross yield will be sustained by the corresponding amount of artificial storage in 19 out of every 20 years. The method used in computing the storage ratios assumes no deficiencies in these 19 years. The method does not provide any estimate of the duration or magnitude of the deficiencies that can be expected in the one remaining year out of every 20.

It is also emphasized that the term, recurrence interval, does not imply any regularity or sequence of droughts. The 20-year recurrence interval, for example, refers only to the average interval between droughts of a given or greater severity. It means that one out of every 20 years, or five per cent of the years, over a long period of time will experience droughts greater in severity than a given drought. The five per cent of years with more severe droughts may include years less than 20 years apart on the calendar, and may include two or more years in succession.

Appendix C - Reservoirs, Lakes and Ponds

Appendix C in each study-area report includes reservoirs, lakes and ponds listed in the 1961 Maryland Impoundments Inventory by the Department of Game and Inland Fish. This inventory was limited to those impoundments open to the public for recreational use. Farm ponds, of which there are over 4,000 in the State, were excluded since their recreational use is left to the discretion of the individual property owner.

The distinction generally made between a pond and a lake is according to either a limnological criterion (thermal stratification) or one based on size alone. A reservoir normally refers to a man-made impoundment serving such utilitarian functions as water supply or power generation. The naming of bodies of water in Maryland has been inconsistent, however, the State Department of Game and Inland Fish uses the following criteria in water resource identification:

> pond - any impoundment under 5 acres in size. The "farm pond" is included in this classification and refers only to the location (i.e., on a farm or in a rural area) of such impoundments.
>
> reservoir - impoundment over 5 acres serving utilitarian function as illustrated above.
>
> lake - impoundment over 5 acres used primarily for recreation.

The Department of Game and Inland Fish recently made a study of farm ponds and published its findings in a report dated December, 1964. A summary of this report is found under the section entitled herein WATER RESOURCE REGULATION AND DISTRIBUTION (p. 18).

Appendices E and F - Surface and Ground Water Permits

Appendices E and F list surface and ground water permits, respectively, as well as other information pertinent to each of the permit holders. Because of exemptions these lists represent only a small percentage of the total water withdrawn from surface and ground water sources. Dependence on other sources of data was therefore necessary in preparing inventories of water use found in this study.

The Maryland Water Resources Law of 1933, as amended in 1964, requires that (with important exceptions) anyone taking water from a surface or underground source obtain a permit from the Department of Water Resources. The exceptions are (1) those users taking water before

January 1, 1934; (2) those using water for domestic and farming purposes; and (3) those taking water for municipal supplies. In effect, the law is applicable only to commercial and industrial users having a privately-owned well or withdrawing water directly from a stream. When supplied by a municipal water system, these users are also exempted from the permit regulation.

Appendix G - Industrial Water Users Supplied by the City of Baltimore

Appendix G, found only in the Chesapeake Bay Western Shore report, contains an alphabetical listing of industrial water users supplied by the Baltimore water system. The listing includes the following data for each firm: standard industrial classification number, number of employees and water used (in mgd) during 1959-1960.

Appendix H - Abstracts of Published Reports on Ground Water Resources

The ground water resources of Maryland have been studied rather extensively for many years by the U. S. Geological Survey in cooperation with the Maryland Geological Survey (formerly the State Department of Geology, Mines and Water Resources. The accounts of these studies have been presented in detailed reports published by the State cooperating agency. Abstracts of these publications are included as Appendix H to each of the study-area reports.

WATER RESOURCE REGULATION AND DISTRIBUTION

Regulation and distribution by means of reservoirs, canals and aqueducts are discussed in each of the study area narratives. Also discussed are diversions and underground storage possibilities. Reservoirs and other impoundments except for farm ponds are listed with pertinent data in Appendix C of each report.

Information on Maryland farm ponds is contained in a recent report of the State Department of Game and Inland Fish (Barry, 1964). The survey data within that report have been extended for purposes of this summary so that total figures for regions, drainage basins and the State can be estimated. Conclusions of the report pertinent to this study are as follows:

1. Almost non-existent prior to 1940, farm ponds now number over 4,200, largely as a result of Federal and State assistance programs during the last 25 years.

2. Farm ponds average in size from 0.4 in the Lower Eastern Shore to 1.1 acres in the Upper Eastern Shore with a State-wide average of 0.75 acres; 36 per cent have a water area of less than 10 acres.

3. Fifty-three per cent of the ponds sampled drain a watershed area of 10-100 acres.

4. Springs provide water for 74 per cent of the ponds surveyed; while 21 per cent are supplied by surface runoff from precipitation.

5. Except in the Upper Eastern Shore region, most farmers follow similar engineering specifications allowing for a maximum pond depth of 9 feet, which results in fairly uniform storage per acre of about 0.3 acre-feet. Ponds in the Upper Eastern Shore average 9½ feet in maximum depth and have an average storage per acre of 0.55 acre-feet.

6. Maryland farm ponds total 2,153 acres and have a capacity of 9,801 acre-feet (3.2 billion gallons).

7. Construction costs for ponds were reported as follows: $100-$500 - 45%; $500-$1,000 - 35%; over $1,000 - 20%.

8. The survey indicated the major reasons for pond construction, in order of importance, were: fire protection (78%), fishing (71%), stock water (43%), irrigation (37%), swimming (29%), and farm beautification (18%).

Although farm ponds under one acre are generally not considered satisfactory for fishing (Bennett, 1962), an estimated 240,000 trips totalling 312,000 visitor-hours annually are made to Maryland ponds for this purpose. The 1962 annual catch was estimated at 90,000 fish (mostly bass and bluegills) weighing 30,000 pounds. Since farm ponds are found mostly on private land their use for recreation is left to the discretion of the individual property owner. The survey indicated that the "public" using farm ponds for fishing is composed largely (80%) of relatives or friends of the owner.

INVENTORY OF SURFACE WATER USES

Surface water uses can be classified as withdrawal, instream, flow, on-site, consumptive or non-consumptive uses. Withdrawal uses, those which require removal of the water from a waterway, include public water supply, industrial cooling and processing, fire fighting and irrigation. Instream uses, those which do not require removal of water from a waterway, include navigation, recreation, fishing, propagation of fish and other aquatic life, livestock watering, hydroelectric power generation, and waste removal and assimilation.

Flow uses are a further classification of instream uses. A flow use requires moving water, while an on-site use does not. Most instream uses either require or can be accommodated by both flowing and non-flowing water. For example, hydroelectric power generation is a flow use because it requires moving water to spin turbines, but many hydropower facilities include a dam and reservoir to create a hydraulic head, that is, a difference in water elevations. The maintenance of the hydraulic head can be considered an on-site use of water. Waste disposal is another example of an instream use which involves on-site and flowing water. Non-flowing water has some capacity to assimilate wastes discharged into it, but this capacity is generally enhanced by a flowing condition. Similarly, navigation may utilize non-flowing water, or it may be aided or hindered by moving water, depending upon the relative directions of the vessel and water motions. Trips by vessels in tidal waters are frequently routed or scheduled to take advantage of tidal currents. Even fishing depends on flowing and non-flowing water . Trout fishing usually goes with flowing water, while bass fishing more often than not is an on-site use. Since all instream uses can be described as both flow uses and on-site uses, no attempt is made in this report to place specific instream uses in either category.

Much of the water resource literature employs the terms water use and water consumption interchangeably. Recently, there have been several attempts to give the latter term a more restricted meaning. The goal of these attempts has been to distinguish between water which is used but not permanently removed from the available supply and water which is so removed. About twelve years ago, a committee of the American Water Works Association (A.W.W.A., 1953) proposed a definition of consumptive use, modified slightly by Carbaugh et al (1960), to include water losses in air conditioning. The modified definition is:

> Consumptive Use (or Consumption): Water used in connection with vegetative growth, food processing, air conditioning, or incidental to an industrial process, which is discharged to the atmosphere or incorporated in the products of the process.

This definition is used for purposes of this report.

Withdrawal Uses - Information on Supplementary Irrigation

Several factors have contributed to the increasing popularity of supplemental irrigation in the humid states along the Eastern Seaboard. One such factor has been the recent development of lightweight pipe made of plastics or aluminum. Because of their lightness and portability they can be shifted from one field to another as needed by one or two men, thus requiring a minimum investment for pipes and labor. This method is cheaper than using the older, heavier types of pipe which could not be shifted easily. For this reason, more pipe was required with the older materials. Another lightweight pipe factor promoting irrigation is the growth of rental agencies which, for a fee, provide portable pipes and pumps during periods of soil moisture deficiency. These rentals allow farmers to irrigate as necessary without making large investments in equipment.

Education has also been a factor in the increased use of supplemental irrigation. Agencies of the Federal and state governments have encouraged farmers to adopt the practice. The Soil Conservation Service and other agencies of the U. S. Department of Agriculture have carried on an active program of assistance to farmers in planning and financing farm ponds. State agricultural colleges and experiment stations have carried out experiments which have shown the value of increasing the moisture available to the crops.

The use of supplemental irrigation has also been influenced by the size of the farm unit - with the average size increasing many more farms now can justify economically the installation of irrigation facilities. At the same time, total acreage in use for agricultural purposes is decreasing because of expanding urban development. This shift from agriculture to residential and commercial land uses is particularly evident in the Baltimore and D. C. Metropolitan Areas. The decreasing acreage of cropland (U. S. Department of Agriculture, 1957) has created a demand for more intensive use of the remaining farms by reason of an increasing population demanding more food and fibre products. Meeting these requirements and the cost-price squeeze has encouraged the more efficient farming practices that include irrigation.

Data available on irrigation in the State indicates that the total water used for this purpose is small. More importantly, however, nearly all of the water used for irrigation is consumed through evaporation, transpiration or incorporation by the irrigated crops. This result differs from Western irrigating practices which apply water in excess in order to prevent salts from accumulating in the soil in the plant's root zone. Consequently, there is some return flow from irrigated fields to streams in Western regions whereas in the East there will be none. This is possible because more frequent rainfall can be expected in the East and is depended upon to leach out any salts created in the soil by the evapotranspiration of irrigation water. For planning purposes in the East, it is more accurate to assume total consumption of irrigation water, although there may be return flows due to intermittently inefficient irrigating practices or rainfall occurring occasionally after the application of irrigation water to a field.

Although irrigation accounts for only a small part of the water used in the State, withdrawals from small streams for this purpose can be quite significant in their effects on the streamflows of these streams during low-flow periods. For example, McComas (1957) of the Maryland Department of Health reported that:

> Some years back one of our public water supplies taking water from a surface stream found the stream had ceased to flow. Investigation disclosed that upstream use for the irrigation of peach and apple orchards was the cause. By the same token, we are skeptical of low-flow rates at the gage on this stream because there are no recorded records of water diversion for irrigation purposes. A similar situation developed a few summers ago when a fair-size stream suddenly, one day, ceased to flow, started again, stopped again, and started again.

The streams involved in these cases were not identified in the published report by McComas; they are mentioned here only as illustrations of the potential effects that irrigators may have on streamflows depended upon for other purposes. If the surface-water use for irrigation has increased significantly beyond that indicated for 1957 by Meyer (1957), and if this increased use is concentrated along a relatively few small streams, these streams could be dried up when the demands for water supply and other purposes are at their annual peak. This has been a matter of concern for some time among those responsible for the design of public water supply and sewage-disposal works. For example, Wiseman (1955) discussed the problems created when streamflows were drastically reduced by withdrawals upstream for supplemental irrigation from streams that were normally adequate for dilution of wastes treated in plants designed for those flows.

Singewald (1945, 1957, 1958) has repeatedly stressed the need to amend the State's Water Resources Law in order to bring irrigational uses under its control. According to Singewald, amending the law would not decrease the water resources available for irrigation nor adversely affect obtaining the supply, but instead, such control would:

1. protect the irrigator against the problems created by improperly placed wells (e.g., salt-water intrusion overlapping cones of depression) and
2. clarify and define the uncertain rights of riparian owners, as well as non-riparians who at present have no rights to the surface waters.

The question of the legal rights of irrigators and those of other, potentially conflicting water users is beyond the scope of this report. For information on this aspect of irrigation, refer to Busby (1954), Critchlow (1952) and Singewald (1957).

Instream Uses - Information on Waste Disposal

Although the use of surface waterways for the disposal of the vast quantities of waste waters from cities and factories is frowned upon by many, it must be recognized that there is no practical alternative for this general practice at present. The high standard of living prevalent in most of Maryland, as elsewhere in the United States, is heavily dependent upon the use of water to receive treated wastes. This instream use of water will diminish as technological innovations eventually provide suitable alternatives for treating waste waters.

The capacity of a surface waterway to absorb wastes without undue degradation of the quality of the stream water is commonly called the waste-assimilative capacity of the waterway. The factors controlling a stream's assimilative capacity are many and extremely complex, so much so that the determination of the capacity is an exacting science. Methods have been developed which evaluate a stream's capacity to assimilate waste to a reasonable degree of accuracy. This determines the design of treatment facilities for a given volume of waste so that upon discharge to a watercourse treated wastes do not exceed the stream's waste-assimilative capacity.

The dilution of wastes, after a reasonable degree of treatment, is usually necessary to protect downstream water uses. Adequate flows must be maintained in waste-receiving streams for this purpose. Thus, the instream use of water for waste disposal places a constraint upon the diversion of such streams and upon the storing of water behind dams for other purposes, such as irrigation or hydroelectric power. The use of State waters for receiving properly treated wastes must be shared equitably with other legitimate water uses.

WATER QUALITY

It is not enough to consider the quantities of water available and used in evaluating the water resources of an area. The quality of water from various sources, together with the water-quality requirements of many different users, must also be taken into account. The physical, chemical, biological, and sanitary characteristics of water are important to many uses. The problems related to water quality faced by water users vary widely, requiring the attention of the users themselves as well as the public agencies responsible for the control of water quality.

General Criteria

Some time ago a water supply had only to meet three tests to be considered satisfactory. These tests required that the water be clear, cool, and colorless - the three C's of water quality. However, it has been many decades since these simple criteria were adequate for judging the suitability of water for its many uses. As varying demands of water quality have developed, and as water contaminants have increased greatly in number, the characteristics by which water quality is measured have grown apace. The testing and treating of water has become a major part of the business of meeting the demand for water of the right kind, at the right time and at the right place. A complete review here of all the significant criteria of water quality is impossible. Only the most important can be touched upon briefly. For more detailed information on water-quality criteria specialized reports on this subject should be consulted, such as the encyclopedic review by McKee and Wolf (1963).

Chemical Criteria - The chemical characteristics of water are all important in determining its suitability for potable and domestic uses, industrial cooling and processing purposes, and for agricultural uses. One of the most exacting uses of water is that of steam generation of electric energy. This is especially true for the newer high-pressure boilers which operate at pressures of several thousands of pounds per square inch and at very high temperatures. These conditions aggravate problems of scaling and corrosion, and therefore require water of much greater purity than in the older low-pressure boilers.

Soluble silica is among the impurities that cannot be tolerated in high concentrations, and causes difficulty even at extremely low concentrations. Silica forms a hard dense scale on heating surfaces in boilers and on the blades of steam turbines, thus causing a reduction of efficiency and generating capacity.

Hardness is a chemical characteristic of water familiar to almost everyone. Travelers easily notice the difference in hardness of waters used for bathing because of its effect on lathering with soap. Hardness is caused by dissolved forms of calcium and magnesium primarily as bicarbonates and sulfates, but sometimes also as chlorides or nitrates. Ground water, especially in limestone regions, frequently contains more hardness-causing constituents than surface water of the same locale. However, during dry periods when streams are fed mostly by ground-water seepage, the stream-water hardness may approach that of the ground water.

Iron is a very common substance found in ground waters of the State. The Public Health Service (1963) recommends that maximum concentrations of iron do not exceed 0.3 mg/l. Higher iron concentrations cause staining of fabrics laundered in the water and also stain kitchen and bathroom fixtures. The rust-colored precipitate which forms in iron-bearing water on exposure to air and along with its poor taste makes such water undesirable for drinking and cooking also.

Fluorides are desirable in potable water supplies in concentrations of about 1.0 mg/l. It has been found that such concentrations reduce the incidence of dental caries. On the other hand, high concentrations of the same constituent causes unsightly mottling of teeth.

Chlorides are especially important as a water-quality criterion in the Chesapeake Bay region. Much of the available water is brackish, exceeding the concentrations of chlorides acceptable for most withdrawal purposes, including public water supply. The "Drinking Water Standards" of the Public Health Service (1962) call for a maximum concentration of 250 mg/l of chlorides (as Cl). This generally rules out the tidal waterways as sources of potable water unless expensive methods of desalinization are employed. It is worthy to note, however, that it is not uncommon to find higher concentrations in public water supplies. For example, according to a report by the Geological Survey (Lohr and Love, 1954) Galveston, Texas, has 422 mg/l of chlorides in its finished water supply serving a population of about 80,000 in 1952. The concentration in the Grafton, North Dakota supply, serving a population of about 5,000, was found to be 1,940 mg/l. The 1954 report showed 10 public water supplies with chloride concentrations in excess of 250 mg/l. At the time of the report these 10 systems were serving a combined population of approximately 270,000. This would indicate that at least in emergencies the less saline waters found in the upper reaches of some of the tidal waterways of the State, notably on the Western Shore, could be used for potable supplies without unreasonable risk to health. However, the use of these waters would create problems of corrosion in water mains and household plumbing fixtures.

Sulfates are undesirable in municipal water supplies because it is believed they can lead to deterioration of concrete structures in contact with the water. Such damage has been reported in concrete sewer lines of cities using high-sulfate water supplies (Powell Engineers, 1957). As in the cases of chlorides, high concentrations of sulfates (75 mg/l or more) are found in many municipal water supplies of the United States. The Geological Survey (Lohr and Love, 1954a, 1954b) reports 84 such supplies, each serving a population of 25,000 or more in 1952. Of these 84 systems, 39 served populations in excess of 50,000 each. Damage to sewage systems has been reported in some of these cities. In others, clay pipe or special types of concrete have been used in sewers and other structures to avoid this difficulty.

Physical Criteria - Important physical characteristics of water include temperature, turbidity, and color. Temperature varies widely with the seasons, especially in surface waters. For this reason, ground water is frequently used in systems where a relatively constant temperature is desirable. For cooling systems, especially air conditioning, ground water is preferable in warm seasons because it is cooler than surface water. Potable supplies are more palatable if cool. However, cool potable supplies are not as necessary as they were at one time with modern refrigerating equipment and ice readily available to cool drinking water in most homes and restaurants.

Turbidity, caused by suspended silt and other solids, creates various detrimental conditions. Silt-laden streams dump their suspended loads in reservoirs destroying storage capacity. Sedimentation in estuaries requires removal via expensive dredging if adequate depths are to be maintained in shipping channels and harbors. Heavy silt deposits in waterways, resulting from soil erosion, reduces the water-carrying capacity of streams, thus causing them to overflow their banks during floods. Silt deposits are harmful to fish and shellfish spawning habitats. Heavy turbidity decreases the depth to which sunlight can penetrate in surface waters, thereby decreasing light-dependent photosynthesis and consequently the waters biological productivity. Since photosynthesis is an important source of oxygen in surface waters (Hull, 1963) the reduction of photosynthetic rates resulting from excessive turbidity means an ultimate loss of assimilative capacity for oxygen-demanding wastes.

In water-filtration plants suspended solids and silt can quickly clog filters, thereby shortening filter runs by necessitating more frequent backwashing. However, these materials usually can be removed without difficulty by the use of coagulants.

Offensive color is undesirable in natural waterways for esthetic reasons. Also; it cannot be tolerated in many industrial processes, for example, in paper making and textile manufacturing. Color makes drinking water unappealing, thus discouraging the intake of quantities required for good health.

Sanitary Criteria - The sanitary quality of water is no less important than its chemical and physical characteristics. Of primary concern is the maintenance of public water supplies in a safe condition from the standpoint of health. This means that the water must be free of pathogenic (disease-causing) organisms, toxic materials, and other harmful substances. Esthetically unattractive characteristics, even though not harmful, may be a health factor. For example, water from a known polluted source, even though safe after adequate treatment, may drive thirsty persons to an untreated source which may be contaminated. At best, some of the alternatives to a safe but unesthetic public water supply, such as bottled spring water, are costly. The physiological effects of the vast number of pollutants found in natural waters are largely unknown. A 1960 conference on the physiological aspects of water quality (Public Health Service, 1960) revealed that very little is known about the long-term cumulative effects of ingesting minute concentrations of contaminants which are often found in public drinking waters. Many of these contaminants are not catalogued and new ones are being created as unwanted by-products of new chemical compounds. Most of these impurities are not removed by the normal processes of either waste or water treatment. Many of them resist the self-purification action of streams.

Inorganic Wastes - Inorganic wastes include materials which are chemically stable and/or unstable. Most wastes, including domestic sewage, contain inorganic materials that can cause injury to other water uses if insufficiently dispersed or diluted in the receiving stream. They may be dissolved or suspended, They may be toxic to fish, wildlife, plants and humans. They may aggravate the corrosive properties of the natural water; their effects may be physical, such as the sedimentation of suspended solids to fill up valuable storage space in reservoirs or to decrease the depth of navigation channels. Inorganic wastes may cause color and turbidity in streams, thereby reducing light penetration into the water. Reduced light penetration adversely affects the rate of photosynthesis, a natural process necessary for biological productivity and self-purification of streams. These wastes may be offensive to the senses or to the sensitivities of water users.

Organic Wastes - In chemical parlance, organic matter is any substance which contains the element carbon. For purposes of stream sanitation, organic matter usually means those carbon-containing wastes which are chemically unstable and degradable by bacteria and other micro-organisms. The outstanding characteristic of organic wastes is their negative effect on the oxygen dissolved in the water of the receiving stream. In the stabilization of these wastes, the micro-organisms feeding on them use oxygen. For this reason, the wastes are said to have an oxygen demand, commonly called biochemical oxygen demand, or BOD. If the BOD load discharged into a stream is significantly large, the dissolved oxygen concentrations in the stream are reduced, resulting in an oxygen "sag" below the point of waste discharge. With very heavy BOD loads, the stream's oxygen-replenishing resources may be overwhelmed, resulting in zero oxygen levels, or levels lower than those necessary to sustain a health biota in the stream.

Waste Heat - Almost every withdrawal use of water adds heat which affects subsequent uses of the water. The most common source of large heat discharges is the steam-condensing system of thermal-electric power generating plants. Other sources include textile mills, distilleries, steel mills, pulp and paper mills, commercial laundries and domestic households. The quantities of heat added to streams with used water are very great, in some cases great enough to alter markedly the natural temperatures of the receiving waters.

The increased temperature of streams by waste heat affects their use for many purposes. Extreme temperature increases will harm fish and other aquatic life. Swimming is discouraged in waters heated above the comfort level. Taste and odor producing algae and other undesirable organisms are stimulated by moderate temperature rises.

Temperature is an important factor controlling the capacity of a stream to assimilate organic or other oxygen-demanding wastes. A rise in temperature increases the rate of oxygen use in the BOD reaction up to the point of thermal inhibition of the micro-organisms involved. On the other hand, the rate of oxygen absorption from the atmosphere by the water also increases with temperature for a given oxygen deficit. However, the saturation concentration of oxygen in water decreases with rising temperature. The net result of these three temperature effects is a reduction of the waste-assimilative capacity of a stream receiving heated discharges. This is shown by comparison of the relatively high winter concentrations of dissolved oxygen in waste-receiving streams with the low concentrations observed in summer.

The temperature of water influences the effectiveness of filtration and other treatment processes in municipal and industrial water works. According to Streeter (1933), filtration is less effective at higher temperatures, but chlorination is more effective. Velz (1934) found that larger dosages of alum were required for removal of color colloids in high-temperature waters than in low-temperature waters.

Low-temperature water is a commodity of considerable value for use in cooling and air conditioning. Corrosion of water mains and other pipes and fixtures is aggravated by increased temperature. Gurnham (1955) has observed that high-temperature wastes accelerate the onset of septic conditions in sewers. Therefore, each coolant (heat additive) use decreases the value for subsequent re-use for the same purposes.

Water quality criteria cannot be discussed adequately in all of their aspects here or even in those aspects significant in relation to water resources of the State. The subject is too broad and complex for complete treatment in a report of limited scope. Additional information on this subject can be found in readily available references, such as the reports by the Public Health Service (1960, 1963) and McKee and Wolf (1963).

Water Quality Control

The control of water quality is vested in various agencies of the Federal government, the State of Maryland, and local governments. Although no interstate agencies now exercise any controls over Maryland streams, basin-wide organizations with some regulatory functions probably will be established for the Susquehanna and Potomac River basins within the next few years.

Federal Agencies - Within the Federal Government, the agency most responsible for control of water pollution is the Federal Water Pollution Control Agency (FWPCA), a branch of the U. S. Department of Interior. The FWPCA, under the supervision of an Assistant Secretary for Water Pollution Control and an agency Commissioner, administers the Federal Water Pollution Control Act, the Water Quality Acts, the Clean Water Restoration Act and their amendments. These laws provide for the prevention or correction of pollution in interstate waters and also in many intrastate waters which are tributary to the former. The laws also provide for Federal grants to communities for the construction of sewage-treatment facilities. Under present financial matching programs local communities can qualify for up to 80 per cent combined Federal-State aid grants. In the last fiscal year (1968) approximately 50 local applications were received by the Maryland State Health Department for projects costing about 65.4 million dollars. Until Federal matching funds are made available on an as needed basis the State is financing on a combined grant/loan basis up to 75 - 80 per cent of sewage treatment facility costs.

The Federal Water Pollution Control Act, enacted in 1956, was amended in 1961 to direct the Public Health Service (now responsibilities of FWPCA) to "... collect and disseminate basic data on chemical, physical, and biological water quality insofar as such data or other information relate to water pollution and the prevention and control thereof." In response to this provision of the law, FWPCA has established a national network of water pollution sampling stations which are maintained in cooperation with state, interstate, and local governmental agencies. As of this time (1968), four "Water Pollution Surveillance System" stations have been established in the Potomac basin (Hagerstown, Berryville and two at Washington, D. C.) and one in the Susquehanna basin (Conowingo Dam).

The Public Health Service described its pollution abatement activities in a report to the U. S. Senate's Select Committee on National Water Resources (1960). FWPCA is currently engaged in a comprehensive survey of water pollution in the entire Chesapeake Bay drainage area. The PHS has long maintained an active interest in shellfish sanitation in the Bay, as evidenced by the reports of Cumming (1916) and Salley (1963), covering a span of 47 years.

State Agencies - In Maryland, the responsibility for the control of water pollution is shared by two agencies, the State Board of Health and the Department of Water Resources.* According to the Office of the Attorney General of Maryland (Harvey, 1956),

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* A 1964 reorganization changed names and transferred functions of the resource agencies. The Water Pollution Control Commission became the Department of Water Resources and the Department of Geology, Mines and Water Resources was renamed the Maryland Geological Survey. The Department of Water Resources assumed all functions of the Water Pollution Control Commission and the operational functions formerly exercised by the Department of Geology, Mines and Water Resources. The names Department of Water Resources and Water Pollution Control Commission are used interchangeably in this report, depending upon the reference cited.

> It is clear that the responsibility of the State Board of Health relates solely to water pollution conditions which adversely affect the public health or comfort, and does not extend to conditions detrimental to the propagation, cultivation or conservation of animals, fish or aquatic life.

Harvey also states that the responsibility of the Water Pollution Control Commission likewise extends to water-pollution conditions affecting the health and comfort of the public, in addition to conditions affecting natural resources generally. Thus, in the area of public health and comfort, there is overlapping jurisdiction by the two agencies under existing laws. However, by administrative agreement between the two agencies, the State Board of Health discharges the responsibilities of both agencies in controlling pollution from municipal or domestic sewage, and the Department of Water Resources deals only with pollution related to industrial wastes. These practices of the two agencies are reflected in their annual budgets. The State legislature has approved these budgets each year, thus sanctioning the administrative division of responsibilities for water pollution control. Both agencies can receive and administer grants from the Federal government as provided for by the 1956 amendments to the Federal Water Pollution Control Act (Public Law 660).

As stated in a recent report of the Maryland Water Pollution Control Commission (1961):

> It is declared to be the policy of the State of Maryland to protect the waters of the State from despoilment by pollution, to require correction and improvement of all contaminated waters, and to maintain in these waters standards of purity, consistent with the public use and public enjoyment thereof.

In furtherance of this general policy, the Commission has issued a series of regulations. Regulation I, adopted in 1947 and amended in 1950, prohibits the discharge of oil into the surface or ground waters of the State, except in case of emergency imperiling life or property, or in the event of collision or unavoidable accident. Regulation II, adopted in 1947, makes it unlawful for any person to discharge garbage or food containers into or upon the waters of the State.

Regulation III went into effect in 1948 and required the removal of coarse solids from food-plant wastes before discharge. In June, 1952, this regulation was cancelled and food-plant wastes became subject to Regulation IV which is applicable to all industrial wastes.

Regulation IV, adopted in 1948, established standards of quality for industrial wastes before dilution in the receiving waters. These effluent standards are not rigidly applied; the regulation provides for either more or less stringent requirements as necessary or permissable in view of the waste-assimilative capacity of the receiving waters.

Regulation IV-A, adopted in 1955, establishes water-quality standards for the Baltimore Harbor area. This regulation, taking into account the enormous capacity of the harbor to assimilate wastes as reported by Garland (1952), established receiving water standards, as opposed to effluent standards as the primary criteria for measuring and controlling pollution. Regulation IV-A also includes "desirable effluent characteristics." These are not mandatory if the receiving water standards are met.

Regulation V, adopted by the Commission in 1952, requires the submission of reports by any person intending to discharge wastes into any waters of the State at any new location, or by any person intending to alter the quantity or quality of wastes which he is discharging. Reports are also required before construction or alteration of waste-treatment works or outlets.

These regulations remained in effect following the 1964 reorganization with the subsequent creation of a Department of Water Resources which assumed all responsibilities of the Water Pollution Control Commission.

The 1964 Water Resources Law is available in booklet form. This law transferred all functions of the Water Pollution Control Commission and certain operational responsibilities of the former Department of Geology, Mines and Water Resources (now Maryland Geological Survey) to a newly created State Department of Water Resources. A 1965 publication of the Department, State of Maryland Water Resources Regulations and Rules of Procedure, contains the agency's regulations and rules of procedure.

In 1964 the State Board of Health adopted more stringent regulations for the control of septic tanks in new residential developments. In order to insure better subsurface drainage of septic tank effluents, and to decrease the danger of well water pollution, the minimum size for a building lot will depend upon the results of a percolation test. With the best soil conditions, the lot must be 100 feet wide and 20,000 square feet in area. For worse soil conditions the required lot size must be greater, up to 150 feet in width and 40,000 square feet in area. If soil conditions are not adequate for the latter size, the Board will deny a permit for septic tank construction (Anonymous, 1964). These restrictions apply only to developments served by individual household systems for both water supply and sewage disposal. If served by public sewers (but not a public water supply) lots are limited in size to 10,000 square feet. If the reverse situation exists (public water supply but no public sewerage) lot areas may vary from 15,000 to 30,000 square feet depending on percolation tests.

Water Quality Standards

On June 30, 1967, water quality standards promulgated by the State of Maryland became effective. The standards were a result of amendments to the Federal Water Pollution Control Act which stipulated that the Secretary of the Interior would set the standards if the state did not do so. The exercise of federal power in this matter applied only to interstate waters; however, financial incentives in terms of increased federal matching funds for waste treatment facilities was offered to those states preparing standards for all waters within their respective boundaries. Maryland established statewide standards and a plan for their implementation, also required by the law, and these were approved by the Secretary. The standards program of the State now includes newly established criteria for instream water quality as well as the existing effluent regulations.

The procedure for determining instream standards was as follows:

1. All of the waters of the State were classified according to the water uses which were to be protected. In all cases, more than one use was involved. Where major uses changed in a body of water or a river, zones were established.

2. For each water use, water quality criteria were defined. Basic parameters were coliform, D.O., pH, and temperature. Since there were multiple uses involved in each zone, there were multiple criteria applicable.

3. Upon review of the various combinations of uses and corresponding criteria involved, it was determined that nearly all could be classified into 3 groupings or standards: the A Standard for those waters having shellfish harvesting as one of their uses, the B Standard for waters used for public water supply, and a C Standard for waters not used for either shellfish harvesting or public water supply.

Following this procedure, public hearings were held throughout the State and, after further review, the standards were promulgated as a regulation of the Department of Water Resources. The complete regulation, including the standards established for each specific zone delineated, is available in booklet form from the Department.

EVALUATION OF AVAILABLE DATA

The data available on water are classified into four categories for evaluation purposes. The categories are: water resources, ground water, water use and water quality.

Water Resources Data

Data on water resources are important because they make up the "supply" side of the supply and demand equation. Generally, adequate information is available on stream flows in the State. The record of flows in the Gunpowder Falls River, maintained by the City of Baltimore, is one of the oldest in the nation. The U. S. Geological Survey in cooperation with organizations of the State of Maryland has systematically collected stream-flow records for various streams in Maryland since 1896, except for a lapse of 15 years from 1910 until 1924. Currently, the USGS maintains a network of streamflow gaging stations covering most of the important streams of the State. The data are published annually. The latest annual listing of streamflows provides data for 71 gaging stations, in addition to special flow measurements at a number of "partial-record" stations and miscellaneous sites (USGS, 1962). These data, together with the records published earlier for the same and other stations, provide the basis for evaluating surface water supplies at many of these stations, although the periods of record for some are relatively short.

The Maryland Geological Survey (formerly the Department of Geology, Mines and Water Resources) in cooperation with the U. S. Geological Survey has recently completed a three-year study of Maryland streamflow characteristics, as reported by Darling (1962). In his report, Darling presents the recorded annual peak flows for many of the gaging stations, as well as the magnitudes and recurrence intervals of annual low flows for various consecutive day periods of from 7 to 274 days. Also included in Darling's report are duration tables of daily flows for various gaging stations. These data are extremely useful in analyzing the streamflows for purposes of water supply. Darling's data were used in determining the storage requirements for sustaining various levels of streamflow at the gaging sites. (A discussion of this subject is found under DESCRIPTION OF APPENDICES commencing on page 10.)

Ground Water Data - The ground water resources of Maryland have been studied extensively by both the U. S. and Maryland Geological Surveys. These studies have been reported in a series of bulletins published by those agencies. Although several of the bulletins need updating, they do contain generalized descriptions of the aquifers underlying each county of the State. The reports also contain substantial data on individual wells. Pumping tests have been carried out at some locations, but these are too scattered in time and space to give more than localized characteristics of the various aquifers.

Water Use Data

Recent publications of the U. S. Public Health Service (prepared in cooperation with State agencies) provided the most recent information used in the study area reports concerning municipal water supply and waste-disposal use of Maryland streams. At present no comprehensive source of industrial water use and waste disposal data exists for the State although an industrial water study is being conducted by State agencies and the Public Health Service.

The former Maryland Department of Geology, Mines and Water Resources was responsible for administering the State's appropriation and well-drilling permit system until the 1964 reorganization; the system is now under the jurisdiction of the Department of Water Resources. As of 1961, nearly 39,000 well records were on file and about 4,000 have been added each year since. Many of the wells in existence prior to initiation of the permit system (1934) are not included. However, records of surface water users applying for permits have been maintained since 1934. Since the exemptions to the system include (1) withdrawals initiated prior to 1934 and (2) municipal water supplies and water used for domestic and farming purposes, these records are not a comprehensive source of water use.

Water Quality Data

Considerable information on water quality in the State has been collected over a period of many years. However, much of the data are not readily available for general use, but are buried in files of the collecting agencies, or presented in unpublished reports of limited distribution. No agency has attempted to maintain a library of all water quality data for the State, nor has any agency compiled a comprehensive bibliography of reports and publications on water quality. The data retrieval and storage program initiated by the Public Health Service in connection with its Chesapeake Bay-Susquehanna River basins project (see DESCRIPTION OF APPENDICES - Appendix A) is a major effort in correcting this situation.

Until recently collection of water quality data has been carried out only as needed for special studies. There was no coordinated attempt to collect data for general surveillance of water quality throughout the

State. Recently, however, the Department of Water Resources, in cooperation with the Maryland State Department of Health, has inaugurated the "Water-Quality Survey and Study Program" which promises to provide much-needed data on water quality. This project merits continued support. The need for water quality data will increase steadily as growing water demands bring about greater use and re-use of the State's water supplies.

GENERAL REFERENCE SECTION
MARYLAND

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